

Mangroves are Home to Fireflies (*Pteroptyx Tener sp.*) in Malaysia: A Review

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Abstract

A Southeast Asian firefly with distinctively bent wings is called *Pteroptyx tener*. This species is a valuable ecotourism resource in Malaysia because it attracts visitors with its synchronised nocturnal flashing in great numbers on mangrove trees and shrubs. Discovering more on the distribution of aggregating fireflies in Malaysia is the aim of the study. The objectives of this review include the awareness to protect fireflies and their habitats in Malaysia, as well as identifying the type of mangroves and utilising GIS in the process of mapping the location for fireflies in Malaysia. On the other side, it has been noted that firefly numbers are declining. Using GIS approach, it is possible to identify the precise type of mangrove that fireflies need as a congregating site based on the intensity and abundance of fireflies in the surrounding region of the study area. All of these plant species may be found in Peninsular Malaysia regularly in riparian areas, and the majority of them have a connection to fireflies. The mangrove trees along riparian areas are the best places for fireflies to develop their habitat as a source of food and as a location to breed. Despite its low prominence, Lampyridae has a big impact on locals' quality of life and, as a result, the local economy. Throughout Peninsular Malaysia, thousands of these amazing insects carry out their nighttime flashing rituals on riverside trees.

Keywords: Pteroptyx Tener, Firefly Habitats, Mangrove, Firefly Population, Firefly Preservation, Mangrove Conservation, Gis.

Introduction

Firefly (mainly focused in this review: *Pteroptyx Tener*) belongs to the order Coleoptera, which is the largest order of insects (Mckenna & Farrell, 2015). It is a distinctive bent-winged firefly found in Southeast Asia which is easily found in hot and temperate climates. This species lives in mangrove swamps or riverbanks areas to get their food sources easily. For such a small insect like Lampyridae, it has a big influence on the livelihood of the local people and indirectly to the economy. These unique insects perform their nightly flashing panorama in group on riverside trees all around Peninsular Malaysia such as Kuala Selangor, Rembau-Linggi, Kuala

Sepetang, Kerteh River, while in Sabah there are several locations of congregating fireflies such as Garama River, Teratak River, Paitan, Tuaran, Sepilok, Pulau Sakar off the coast of Lahad Datu and Kawang River.

Previous studies have shown that Berembang trees plays a dominant role in the selection of habitat for firefly. Berembang trees is a type of mangrove tree that grows on the shorelines of Peninsular Malaysia (Saib et. al., 2016). The Berembang trees also provide a food supply and a place for breed. Studies of Malaysian firefly colonies at Kuala Sepetang, Kuala Linggi, Sungai Rembau showed that most of fireflies were found at Berembang trees compared to the other type of mangrove trees (Jusoh et. al., 2010). In the Rembau-Linggi estuary, *P. tener* has been found congregating on several tree species such as *Sonneratia caseolaris* and *Talipariti tiliaceum* growing along a 9 km stretch of the brackish river (Jusoh & Hashim, 2012). The riparian area, an interface between land and water, becomes the habitat for a wide range of flora and fauna. Some riparian florals recorded as being found in Malaysia are Berembang, Sea Hibiscus, Nipah Palm, Golden Leather Fern, Betel Palm, Nibong Palm and Weeping Fig. They flash synchronously in order to attract their mating partner for hours after sunset. This species is one of those fireflies with 'perfect synchronization'.

These types of vegetation were commonly found in riparian habitats and are associated with fireflies in Peninsular Malaysia and Thailand. Uniquely, one of the riparian vegetation was the preferable display tree by the synchronous firefly, *P. Tener*, in Malaysia (Abdullah et al., 2019). The purpose of this review is to study the relationship between display trees and congregating fireflies in Malaysia. The objectives of the study are to identify the features of the display trees in Malaysia, to describe the characteristics of the habitats and to map the conservation of mangroves and preservation of firefly along its habitat.

Literature Review

Firefly populations are being impacted by significant changes in the mangrove environment as a result of anthropogenic activities. Mangrove habitat has been severely disrupted as a result of urbanization, agriculture, and logging of mangrove trees for the charcoal business. Other human activities, such as dam building, have depleted the food supply of fireflies, resulting in a reduction in the population size of this distinctive insect. Higher soil acidity and higher metal concentration inhibit firefly larvae from developing and growing, and a lack of community understanding about firefly concerns makes efforts to conserve synchronous fireflies more challenging. Jusoh et al (2010a) documented the presence of synchronous fireflies, their population size, and the plant species on which they gather at the Rembau-Linggi estuary and its tributaries. However, there is limited information about their abundance near Sungai Rembau. It's also difficult to ascertain how abiotic variables influence their abundance.

Following the converting of riverbank mangroves to agricultural, aquaculture, and urbanisation in Malaysia, breeding congregations of *P. Tener* fireflies decreased (Lewis, 2021). Vast areas of riverbank mangroves have been removed throughout Southeast Asia for oil palm plantations, shrimp farms, or flood mitigation, making these areas unsuitable for *P. Tener* firefly larvae and their snail prey to continue to thrive. In addition, *P. Tener* adults assemble in certain, prominent trees along mangrove rivers for nocturnal courting displays, and many of these display trees have been destroyed.

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Jusoh et al (2010) explained more than one element might be at mind when it comes to the relationship between firefly population and vegetation compositions. To begin with, although fireflies do not mate on their wings, they use trees as a mating spot (Buck and Buck 1966). Researchers believe that there are five variables that determine the decision to install a display tree: 1. The display tree should be at the riverbank as this encourages fireflies to communicate more easily; 2. Each display tree's leaf structure must be appropriate for mating purposes; 3. The display tree must have nectarines or sap when adult fireflies feed it; 4. The display tree must be near a larval prey food plant and lastly; 5. The display tree must be in good health.

According to Jusoff and Taha (2009), knowledge or data on mangrove destruction is minimal. Being a delicate ecosystem, due to slight changes in the natural climate, mangroves appear to fluctuate. In response to the growing demand for urban and infrastructure growth, beach resorts and aquaculture ponds, rapid development has led to the clearing of mangrove regions. Industries and factories situated near rivers and streams could emit their wastes into the water systems such as waste disposal, toxic draining to the river area, resulting in polluting the river systems area and crippling it (Jusoff & Taha, 2009). When the river or stream was affected by toxic waste required for medical and agricultural purposes such as fertilizers and pesticides, thus may disrupt the ability to protect the coastline naturally.

Throughout the last ten years, Zaiton (2020) stated the number of fireflies has fallen by 42 percent since 2007. This is demonstrated by the fact that the current number of fireflies in each Berembang tree is just 400, down from 600 earlier. The primary contributing cause to the reduction in firefly population is interruption during the early phases of the cycle, namely the larval stage. They eat on three snails each day during the larval stage, which is also the most crucial period. If sago trees, which are also snail habitat, are chopped down, the food source for firefly larvae may be depleted, and the population may suffer as a result.

The *Sonneratia caseolaris-Nypha fruticans* and *Nypha fruticans-Nypha fruticans* assemblages are the most common plant patterns in the firefly habitat (Sulaiman, 2017). The back mangrove ecosystem, which is dominated by the *Nypha* palm, provides shelter for the growing firefly larvae as well as a breeding site for river snails like *Cyclotropis carinata* and other tiny insects, which are the firefly larvae's major source of food. Other mangrove trees

that provide adequate microclimatic conditions for adult fireflies include *Rhizophora apiculata*, *Acrostichum aureum*, *Ficus benjamina*, *Barringtonia asiatica*, and *Daemonorops sp.*, in addition to *Berembang* as the major host plant (Sulaiman, 2017).

It is clear that the publics had just a broad understanding of firefly behavior, lifespan, and threats to their survival, rather than a deep understanding. For instance, people correctly identified a firefly as a bug that emits a flashing light above trees along the river bank at night, but they were mistaken in assuming that fireflies reside in orchard regions rather than on *Berembang* trees. However, the fireflies are found mostly along the streamline where the populations of the mangrove trees nearby with the three species such as *Bakau Minyak*, *Nypa fruticans*, and *Berembang*. The species are mostly found abundantly during the misty and when the sun sets fully and darkens night. Hence, during the heavy rains, the fireflies undergo process mating and covers themselves under the leaves.

Locals were utterly speaking that a big crowd of tourists does not pose a threat to fireflies, but they could not really agree on whether speed boats would damage the riverbank, posing a hazard to the firefly ecology in the long run. Meanwhile, the majority of residents agreed that tree cutting and river pollution were the primary causes of firefly population reduction in terms of habitat degradation, followed by development along riparian areas. However, cutting down the trees should only be able to do in the correct ways since the ancient time. The trees were labelled down to know the age of each tree so that it is easier to track and warn the surroundings.

A narrow stream or channels can be developed in mangroves, their widths depending on site characteristics, with inlets from both seawater and freshwater sources near the mangroves' edge. This allows both freshwater and ocean to flow freely. However, erosion may occur as a result of channel construction in some cases. Before fully implementing this strategy, it is recommended that a sample execution be carried out and monitored. Firefly larvae and some of the snails they eat flourish in brackish water (seawater diluted with freshwater) in the intertidal zone. Leaf litter is beneficial to the larvae and should not be removed as part of usual park maintenance.

Firefly populations are being impacted by significant changes in the mangrove environment as a result of anthropogenic activities. Mangrove habitat has been severely disrupted as a result of urbanization, agriculture, and logging of mangrove trees for the charcoal business. Other human activities, such as dam building, have depleted the food supply of fireflies, resulting in a reduction in the population size of this distinctive insect. Higher soil acidity and higher metal concentration inhibit firefly larvae from developing and growing, and a lack of community understanding about firefly concerns makes efforts to conserve synchronous fireflies more challenging. Jusoh et al (2010a) documented the presence of synchronous fireflies, their population size, and the plant species on which they gather at the Rembau-Linggi estuary and its tributaries. However, there is limited information about their abundance near Sungai Rembau. It's also difficult to ascertain how abiotic variables influence their abundance.

For the conservation of firefly and its habitat, the recommended plants for planting are *Api-api putih* (*Avicennia alba*), *Bakau minyak* (*Rhizophora apiculata*), *Perepat* (*Sonneratia alba*),

Berembang (*Sonneratia caseolaris*), *Nipah* (*Nypa fruticans*), *Piai raya* (*Acrostichum aureum*), *Jeruju hitam* (*Acanthus ebracteatus*), *mangrove fringe*, *Jeruju putih* (*Acanthus ilicifolius*), *Sea hibiscus* (*Hibiscus tiliaceus*) and mangrove fringe (Chan, 2013). Firefly population are depending on the mangroves because a source of clean water, a clean and cold climate, damp and high humidity, and no light pollution are the important attributes for a firefly to choose their habitats. As a contrast, fireflies are unlikely to complete their reproductive cycle if any of these parameters are not satisfied (Chan, 2013). The completed lifecycle of firefly is recommended for the firefly to be reared in the surrounding just like the habitats of mangroves swamps.

Pteroptyx tener has been explored in coastal areas of mangrove ecosystems in Peninsular Malaysia, including the Kerteh River, Sepetang River, Johor River, Sungai Rembau, Selangor River, and Bernam River; in addition, studies on the distribution of *Pteroptyx tener* in Peninsular Malaysia and East Malaysia have been executed (Asri, 2020). Therefore, the previous studies stated that *P. Tener* is the largest population of fireflies in Malaysia and Southeast Asia can be accepted. As a result, it is crucial to keep track of the most significant plant species in the conservation activities for example, *S. caseolaris* was identified as the most important plant species in the research areas because it dominated the riverbanks and supported a diverse range of insects included the priceless firefly, which might be seen of as an umbrella species for the region.

Fireflies are strongly depending on mangroves as their habitats as the mangroves swamps is very damp and the geographical positions of the trees itself shown their resistance to the wind speed. Geographically, mangroves swamps act as an umbrella or shelters to other insects and wildlife while the roots of the mangroves help to grab the land when the tides, waves, or any climate natural disaster are resisting the wetlands. This nocturnal firefly was frequently observed flying over trees, grass, and water, flashing quicker and emitting a long-lasting yellow-green light. Fireflies flew out of the bushes around canals just after sunset and wandered about the area constantly.

Malaysian researchers have recently led the way in monitoring the population of *Pteroptyx* fireflies in response to expanding ecotourism and growing concern about habitat destruction. *Pteroptyx* (mostly *Pteroptyx tener*) abundance, distribution, seasonal change, and the relationship between plant species and firefly congregations have all been studied extensively along various Malaysian rivers, including the Selangor, the Rembau, the Linggi, the Kerteh, and the Sepetang. However, following the converting of riverbank mangroves to agricultural, aquaculture, and urbanisation in Malaysia, breeding congregations of *P. Tener* fireflies decreased (Lewis, 2021). Vast areas of riverbank mangroves have been removed throughout Southeast Asia for oil palm plantations, shrimp farms, or flood mitigation, making these areas unsuitable for *P. Tener* firefly larvae and their snail prey to continue to thrive. In addition, *P. Tener* adults assemble in certain, prominent trees along mangrove rivers for nocturnal courting displays, and many of these display trees have been destroyed.

Malaysia has start conserving firefly population while preserving the mangroves trees as the habitat of firefly and at the same time this conservation and preservation of firefly and its habitat has been contributing in the tourism industry. According to Tourism Malaysia (2019), Malaysia's tourism industry generates RM 84.1 billion per year, with 25.8 million visitors

visiting the nation in 2018. Hence the awareness has been arising among locals to preserve and conserve the habitats in 2010 (Jusoh, 2011). This review has summarized the location of the known attraction in preserving mangroves and conserving fireflies in Peninsular Malaysia. Figure 2 below shows the location of the fireflies congregating in Malaysia which has been summarized by using GIS approach. Moreover, the locations are also involving in tourism industry to help spread awareness on the importance of mangroves swamps to fireflies.

Method

PRISMA Approach

The previous studies includes both reviews and empirical research from prominent publications, most of which were indexed by SCOPUS and some by Web of Science such as major online databases like Elsevier (Science Direct) and Google Scholar. The PRISMA approach (refer Figure 1) was used to carefully and systematically identify relevant research from the pool of literature prior to the in-depth review procedure. Identification, screening and inclusion are all covered by this method's four-phase flow diagram. Computerized searches were conducted using keywords such as mangroves vs firefly, loss of mangroves habitat, display trees, abundance of fireflies impacting firefly, firefly, mangroves. Following then, the identification phase began with the year of the search and lasted ten (10) years from 2011 to 2021. Although this process intends to emphasize the most previous studies on the issues, the year covered is quite recent.

There were 1,456 papers found in the Elsevier database, whereas Google Scholar found 1,185. A total of 2,641 papers were discovered using these two databases. Following this, all duplicated articles were thoroughly examined and removed. To keep duplicate articles out of the review process, this screening is needed. As a consequence, once the duplicates were eliminated, 64 papers were preserved. A screening process based on titles and abstracts was used to assess the appropriateness and relevance of the articles based on these 64 publications. The factors used to evaluate the appropriateness and validity of the articles were based on the study's goals, which focused on mangroves vs. firefly, loss of mangrove habitat, display trees, quantity of fireflies influencing fireflies, and firefly, mangroves. These terms are also essential in calculating the number of fireflies in Malaysia, as well as the use of GIS in firefly habitat preservation. Thirty (30) manuscripts were removed throughout the screening process, reducing the total number of papers in the next phase to 34.

The articles were then further reviewed for the third step on their eligibility of the screened articles, in other words full-text articles accessible for eligibility, based on their entire step and contents. After this procedure, the total number of publications was decreased to 18, and it was assessed whether the articles were truly eligible based on the set criteria and conditions, such as the population of fireflies using a GIS approach and the protection of mangroves in dispersed places. As a result, only 16 final articles were included for review purposes during the inclusion phase, which spanned the years 2011 to 2021, with the year covering changes from the identification phase because some articles were not suitable and related to the topics and aims after the screening and inclusion process. Finally, to address the study goals, an in-depth review was conducted.

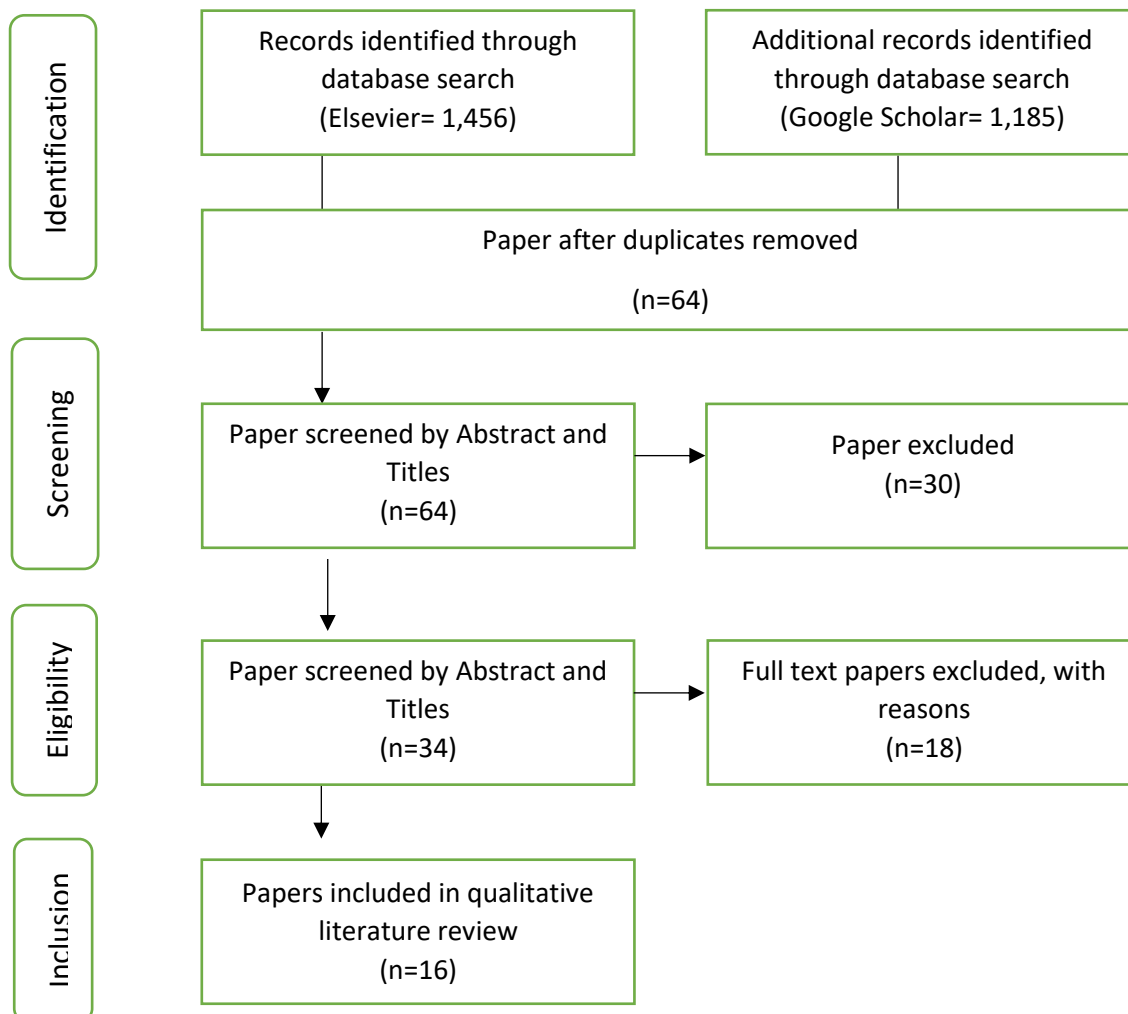


Figure 1. A PRISMA Methodology Flowchart

Source: UNC Health Science Library (2021). Creating a PRISMA flow diagram. Retrieved from <http://pubmed.ncbi.nlm.nih.gov/19631507/>

Discussion

Khoo and Nada (2014) discussed *Sonneratia caseolaris* and *Nypa fruticans* dominate the firefly habitat in Sepetang River, with a mix of *Rhizophora spp.* stands. *Rhizophora spp.* regions are occasionally flooded by river water. The locations stated in this study maps such as Figure 2.1 and Figure 2.2 are all located along riverside. Human activities such as fishing jetty, charcoal factory, prawn farming, and oil palm plantations can be seen along the river. Shaded, wet, and organically rich environments are required for the larvae and snails. Aside from habitat needs, oil palm farms may require pesticide treatment, which might endanger the firefly population's survival. It is advised that the "Firefly Forest Reserve" to have a buffer zone of at least 50 metres on both sides of the riverbank. The buffer zone region should be altered as little as possible and should preferably consist of natural riverine vegetation. These buffer zones are essential for preserving firefly breeding areas while also limiting riverbank erosion.

During new moon nights, Shahara et. al (2017) concluded the percentage cover estimation of fireflies was greater than during full moon nights. During full moon nights, there were brighter sources of light, and the fireflies may have been light sensitive and disoriented by the bright moonlight. This might explain why they're more common on nights when the moon isn't

shining brightly or when light sources are limited. However, it is concluded the male fireflies were more plentiful than the females with a male-to-female ratio of 3:1. Hence, this review only focused on the type of mangrove that firefly preferred as congregating site.

Table 1

List of Vegetations that Fireflies Inhabit

Number	Place	Vegetations
1	Kg Kuantan, Selangor River	<i>Acrostichum aureum</i> , <i>Rhizophora sp.</i> , <i>Sonneratia caseolaris</i> , <i>Ficus sp.</i> , <i>Nypa fruticans</i>
2	Bernam River	<i>Sonneratia caseolaris</i> , <i>Ficus sp.</i>
3	Johor River	<i>Sonneratia caseolaris</i> Engl.
4	Benut River	<i>Sonneratia caseolaris</i> Engl.
5	Endau River	<i>Sonneratia caseolaris</i> Engl.
6	Mawai River	<i>Sonneratia caseolaris</i> Engl.
7	Rembau River	<i>Sonneratia caseolaris</i> Engl., <i>Nypa fruticans</i> , <i>Rhizophora apiculata</i> , <i>Hibiscus tiliaceus</i> and <i>Ficus sp</i>
8	Sepetang River	<i>Acrostichum aureum</i> , <i>Rhizophora sp.</i> , <i>Sonneratia caseolaris</i> ,
9	Setiu	<i>Avicennia alba</i> and <i>Sonneratia alba</i>
10	Kerteh river	<i>Avicennia alba</i> Blume, <i>Barringtonia racemosa</i> (L.) Spreng, <i>Brownlowia argentata</i> Kurtz, <i>Bruguiera gymnorrhiza</i> (L.) Lam, <i>Ceriops decandra</i> (Griff.) Ding Hou, <i>Derris trifoliata</i> Lour, <i>Excoecaria agallocha</i> L., <i>Gluta velutina</i> Blume, <i>Hibiscus tiliaceus</i> L., <i>Nypa fruticans</i> Wurmb, <i>Rhizophora apiculata</i> Blume, <i>Sonneratia caseolaris</i> (L.) Engl., <i>Xylocarpus granatum</i> J. König
11	Sg Linggi	<i>Sonneratia caseolaris</i> and <i>Rhizophora apiculata</i>

Figure 2.1 below shows the location of fireflies congregates in West Malaysia comprises nine (9) stations. However, the Table 1 consists of list of vegetations that fireflies chose as habitats. It can be concluded from the Table 1 that fireflies mostly chose *Sonneratia caseolaris* as their congregating site that acts as their home. From the Table 1, every location in the Peninsular Malaysia has *Sonneratia Caseolaris* or Berembang Trees as the dominated species for preserving firefly.

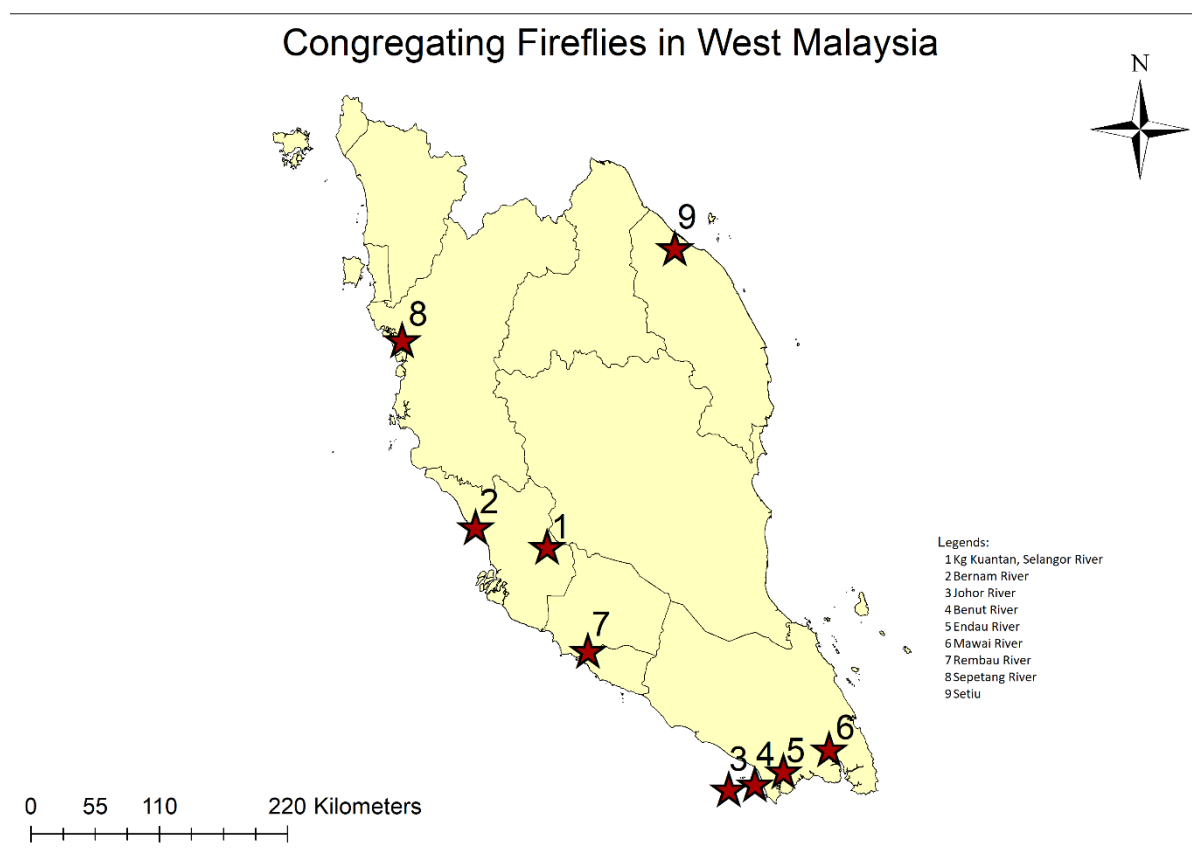


Figure 2. 1: Location of Congregating Fireflies in Peninsular Malaysia

Most published study on East Malaysia mentions the prevalence of firefly trees and their display trees. However, West Malaysian researchers carried out the most of the country's thorough published firefly study. More attention is needed for other regions, such north and east Sabah. Both the intertidal mangrove estuaries and the distinctive congregating fireflies need to be preserved and conserved immediately.

The research of fireflies is becoming a topic of interest since this insect has the potential to become a product for nature tourism in Sabah. Hence, the Figure 2.2 below shows the location of congregating fireflies in Sabah and Sarawak. Their capacity to produce coordinated, rhythmic flashing lights in massive crowds has made them popular. Furthermore, the loss of their natural habitat, mangrove forests, has resulted in their extinction in several areas, necessitating further research. The *Pteroptyx* genus of fireflies has the potential to be used as a nature tourist attraction. This genus is distinguished by vast congregations and synchronized flashing. Currently, there are a few locations in Sabah where we may witness enormous populations of fireflies flashing, with some even displaying mass synchronization (especially *P. tener*, and some said *P. Malaccae*, but not other species in the genus). Almost all other natural habitats, such as those in the Likas region, have been destroyed away with the rest of economic development. Due to anthropogenic disruptions, the mangroves in Likas are no longer suitable for sustaining firefly populations. These disruptions not only bring pollutants to mangrove regions, but also artificial light, which disrupts firefly light communication and finally leads to their extinction.

Table 2

Vegetations list for Sabah and Sarawak

I D	Place	Vegetation
2 3	Balingian River	<i>Sonneratia alba</i>
2 4	Similajau River	<i>Sonneratia alba</i>
2 5	Mukah River	<i>Sonneratia alba</i>
2 6	Kuching, Sarawak	<i>Sonneratia alba</i>
2 7	Paya Paloh	<i>Sonneratia alba</i>
2 8	Saratok	<i>Sonneratia alba</i>
2 9	Garama River	<i>Excoecaria agallocha L., Rhizophora apiculata, Nypa fruticans and Sonneratia alba</i>
3 0	Teratak River	<i>Excoecaria agallocha L., Rhizophora apiculata and Sonneratia alba</i>
3 1	Weston River	<i>Excoecaria agallocha L., Rhizophora apiculata and Sonneratia alba J. Smith</i>
3 2	Abai	<i>Excoecaria agallocha L., Rhizophora apiculata and Sonneratia alba</i>
3 3	Sipitang River	<i>Excoecaria agallocha L., Rhizophora apiculata and Sonneratia alba</i>

Table 2 above illustrated the list for mangroves vegetation that act as home to the firefly especially *Pteroptyx tener sp.* As shown in the Figure 2.2 those vegetations in Table 2 were found according to the location that make homes to firefly. The most preferred mangroves are *Rhizophora apiculata*, *Nypa fruticans* and *Sonneratia alba*. The size of leaves and the feature of the leaves structure give firefly some sort of comfy to act as their mating site and protects them rains and preys.

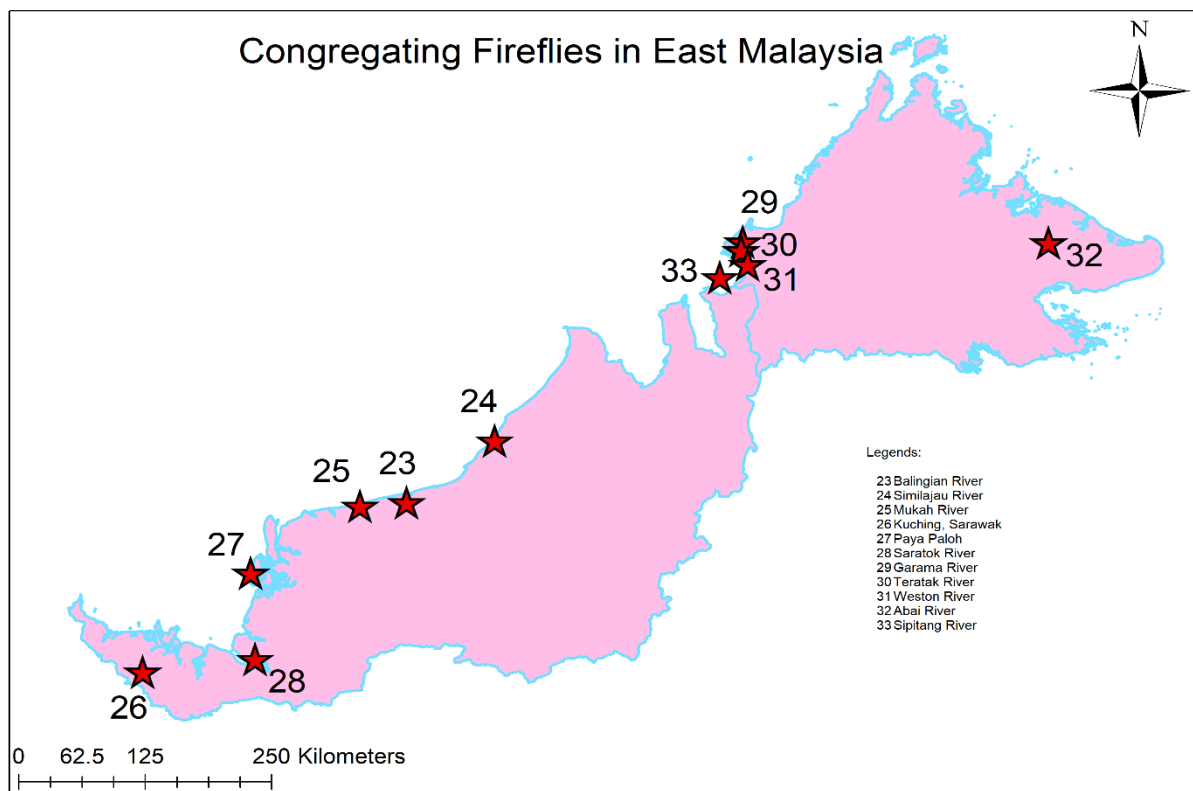


Figure 2. 2: Location of Congregating Fireflies in Sabah and Sarawak

Conclusion and Recommendations

Adaptation of GIS in mapping of mangroves are home to fireflies surely showing some contributions to the ecotourism. This study portrays how GIS is accommodating in giving the best view to pinpoint the locations into maps for locals and authorities with certain information on mangroves. A well-developed GIS system has been a great help to protect environments around the world especially Malaysia as the current study area. Since GIS has been integrated and well-developed, it also has become a great tool in assisting the local and tourists for the further information on preserving and conserving the habitat of fireflies. However, mangroves are actively preserved by the National Forestry Department to enhance the quality preserving any related flora and fauna species by using certain tools in GIS such as Data Management tools, Spatial Analyst tools like Inverse Distance Weighted (IDW) Interpolation and buffer analysis.

In conclusion, many studies have found that the abundance species of fireflies in Malaysia are *Pteroptyx Tener*, and the relationship between firefly and mangroves are obviously depending on each other as the mangroves as the breeding sites for the fireflies to mate, grow and develop. This article is showing compilation of previous studies on how the display trees are visible to attract more ecotourism. However, this study shows mostly in Malaysia, Berembang trees have been chosen as the top mating site for the fireflies due to its biological factors of the tree. This study is important to conserve the firefly in preserving the habitats of mangroves. It has been said along this review that the mangrove trees along riparian areas are the best places for fireflies to develop their habitat as a source of food and as a location to breed. The fireflies chose mangroves as their home due to the leaves structure, temperature and the quality of water along the riverbanks such as the pH, water salinity and water clarity.

For the recommendations, the studies on the ecotourism of firefly effecting the habitats should be able focused on the destructive of the habitats or light pollution. Finally, this study outlines the features of *Pteroptyx Tener* congregations that may form and sustain even in a confined habitat surrounded by human activity. Many of the data suggest that a habitat does not have to be perfect or entirely degraded. To keep the fireflies alive, it's only natural. It was not only foreign plant species that were used, but it was also native plant species that were used.

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